



HSI 2007: HSI in Human Spaceflight

SF3/Susan D. Baggerman
March 21, 2007

HSI 2007 – Panel 3: Where HSI Meets the Road

HSI in Human Spaceflight

Susan D. Baggerman

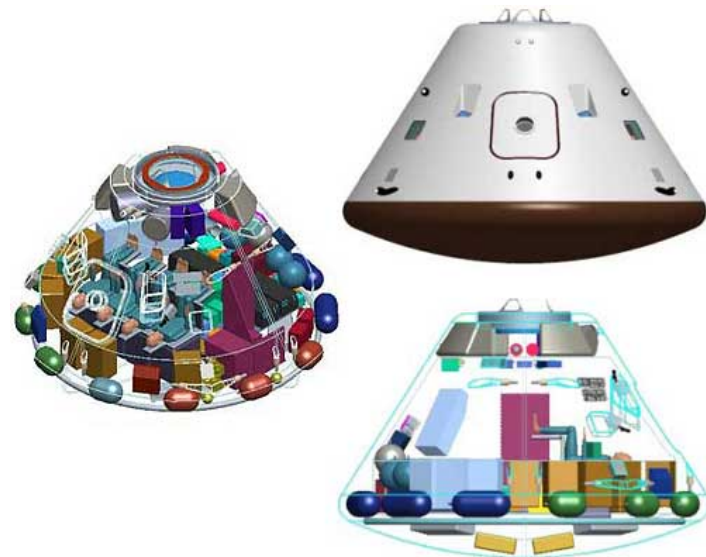
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Overview

- Scope of HSI at NASA
- HSI Implementation in Human Spaceflight Programs
 - International Space Station (ISS)
 - Responsibilities
 - Lessons Learned
 - Constellation (Exploration) Program: Crew Exploration Vehicle (CEV)
 - Strategy/approach





HSI – what it means to us...

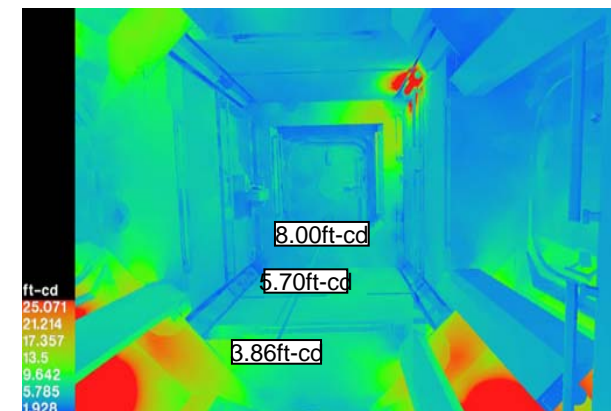
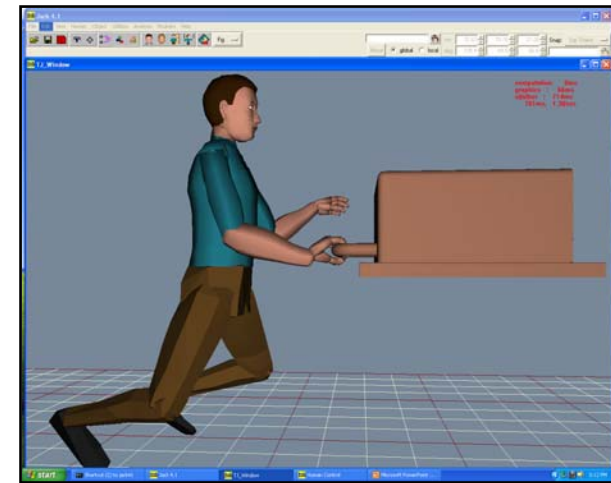
- The current scope of HSI at NASA is focused on the Human Engineering and Habitability domains of DoD's PRINT
 - Primary areas of emphasis are:
 - Anthropometry/biomechanics
 - Crew functions/habitability
 - Lighting/acoustics
 - Architecture
 - Maintenance
 - Crew hardware/equipment
 - Displays/controls
 - Labeling
- The definition of “HSI” is expanding at NASA with the Constellation Program through the Human-Systems Integration Requirements (HSIR) document
 - Includes sections on:
 - Natural/Induced Environments
 - Space Medicine
 - Ground Maintenance and Assembly





HSI on the International Space Station (ISS)

- The HSI team for ISS is known as “Flight Crew Integration (FCI)”
 - FCI has been a recognized system in the ISS Program’s system engineering hierarchy since the late 1980s
- FCI Responsibilities
 - Requirements
 - Generation and flowdown
 - Verification
 - Design
 - Modules
 - Projects
 - Labeling
 - Operations
 - Sustaining engineering
 - Anomaly/issue resolution





HSI in the Constellation Program

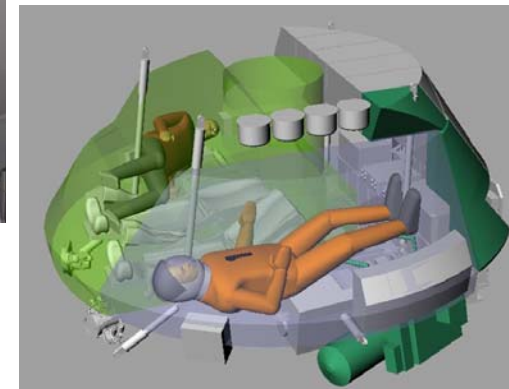
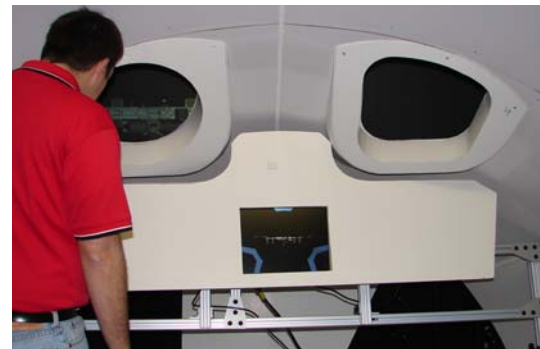
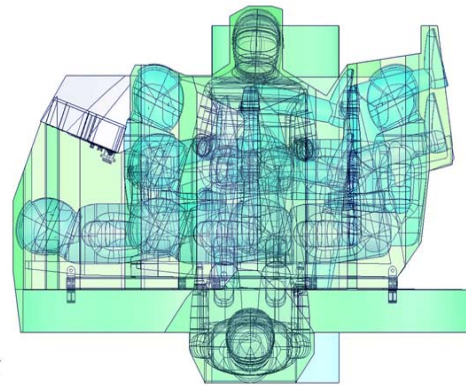
- HSI is being implemented at every level
 - Level 1 (NASA Headquarters):
 - Today: Human Rating Requirements (invokes inclusion of NASA-STD-3000)
 - Soon: Space Flight Human Systems Standards (invoked directly by NASA Health and Medical Policy Directive)
 - Level 2 (Program-Level):
 - Human Systems Integration Group (HSIG)
 - Human-Systems Integration Requirements (HSIR)
 - Level 3 (Project-Level):
 - Crew Exploration Vehicle (CEV) Human Engineering System
 - CEV Radiation System
 - CEV Crew Health Interfaces Systems
 - CEV Food Interfaces System
 - Level 4 (Prime Contractor-Level):
 - CEV: Lockheed-Martin Human Engineering Team, other technical HS teams (radiation, etc.)





HSI Team in the CEV Project Office:

- Responsibilities
 - Requirements
 - Design & Analysis
 - System Integration
 - Verification
 - Information Display & Design
 - Operational Integration





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Back-up Charts

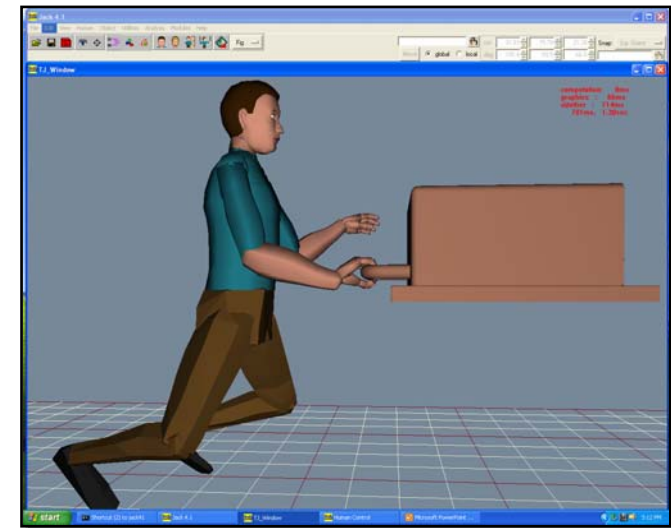


Requirements

- FCI is uniquely responsible for ISS Program Office human factors (SSP 50005) requirements
- Work with module and hardware developers to provide human factors integration, including item-specific functional requirements for crew interfaces
- Analyze and evaluate compliance of designs with human factors requirements and principles
- When necessary, evaluate and process waivers and Interpretation Memos to SSP 50005 requirements

• Example – Handle clearance for Water Processor Assembly

- **Requirement:**
 - Handle clearance of 1.875"
- **Non-compliance:**
 - Current handle design has a clearance of 1.16"
- **Waiver evaluation:**
 - Modification of crew procedure
 - Fit check performed to ensure operability by a full range of crew members



Representation of operation only—
not anthropometrically accurate



Design

- Work with module and hardware developers to provide human factors design expertise
- Provide human factors analysis for specific issues via the Space Human Factors Labs
- Provide conceptual human-centered design support during the early phases of the project
- Provide recommended design implementation (via Decal Catalog) for ISS labeling requirements to ensure readability and consistency

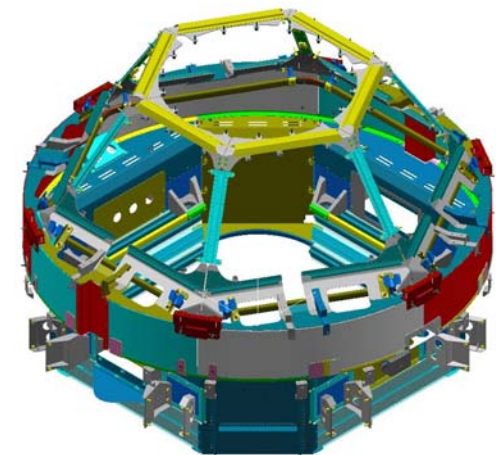
• Example - Cupola:

– Concern:

- Placement of Robotic Work Station (RWS) inside the Cupola precluded view out the windows at the RWS
- Design of the Cupola foot restraints did not fit 95th percentile male
- Developer's assessment of anthropometry was inadequate; resulted in 3-D models and full scale mock-up evaluations

– Beneficial design changes based on FCI guidance

- Hardware design corrected early in design process by participating in full scale mock-up reviews and crew reviews
 - Would not have occurred if FCI did not review hardware design
- Design modifications reviewed by the crew who were pleased with the improvements to the design





Operations

- Address and pursue resolution for current on-board ISS human factors and habitability issues
 - Provide real-time support as needed to Mission Operations for human factors issues that arise during an ISS Increment
 - Collect post-flight data from Expedition crewmembers to determine and resolve issues

• Example – Internal Lighting Assessment:

– Issue:

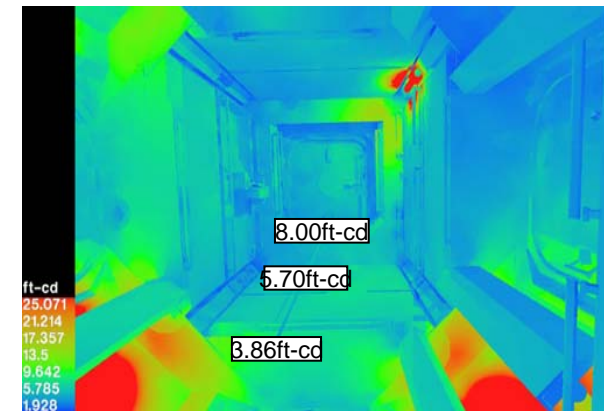
- Internal lights on ISS were failing at rates greater than expected
- Spare lights were not available due manifest limitations associated with the grounding of the Shuttle

– Human Factors Concern:

- On-orbit lighting levels were falling below requirements and may pose a risk to the crew for safe, productive operations
- No light meter is available onboard to verify lighting levels

– Issue Resolution:

- FCI provides analysis for current lighting levels to Mission Operations each time the lighting scenario changes (a light fails or spares are launched/installed)





Examples of HSI ISS Lessons Learned

Lack of Human-Centered Design



ISS008E06104

Excessive Noise Levels



Excessive On-Orbit Stowage



ISS007E08022

Poor Usability of Procedures



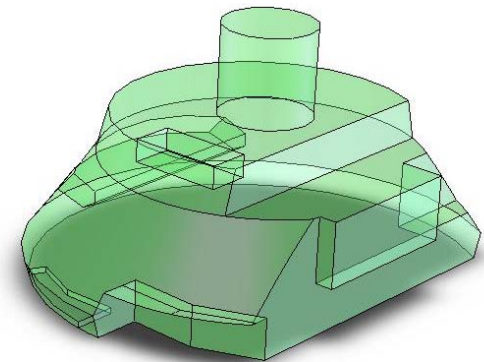
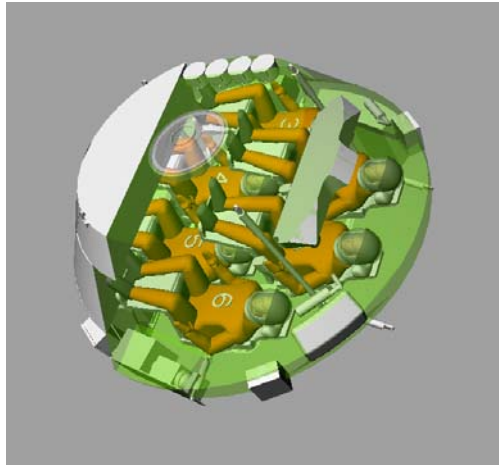
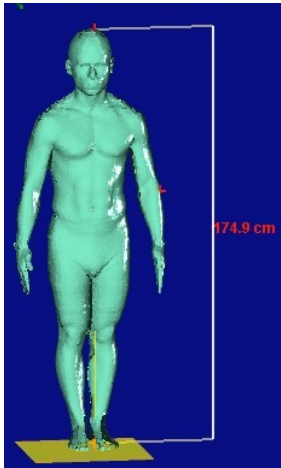
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CEV HE Support



Example of HSI Assessment for CEV—Net Habitable Volume:



↑
**Anthropometric
measurements**

↑
**Graphical
analysis**

↑
**Mockup
review**

↑
**Verification
criteria**

CEV HE Support

- **Constellation**
 - HF SIG
 - EVA SIG
 - Supportability SIG
 -
 -
 -

- **CEV**
 - EVA Systems
 -
 -

Vehicle Integration

Crew Module

Service Module

Launch Abort System

Test & Verification

CEV Cockpit WG

- Crew
- Engineering
- Operations
- **Human Factors**

Human Engineering Systems Integration Team

- Anthropometry / Biomechanics
- Usability / User Interfaces
- Crew / Stakeholder Evaluations
- Rapid Prototyping / Lo-fi Mockups
- Early Conceptual Design
- Human Modeling, Lighting Analysis
- HFE Requirements Development
- Design Review Support
- Test & Verification Support
- Liaison to Level 2 HF

- CEV Human Systems
 - Operations
 - FSW, Avionics, Cockpit
 - Structures and Mechanisms
 - Power & Propulsion
 - Landing & Recovery
 -
 -
 -

- ECLSS/ATCS System
- Habitation Accommodations
- Suits / EVA / Crew Survival Equipment Interfaces System
- Radiation System
- Crew Health Interfaces
- **Human Engineering**